Town of Prescott Valley
Rainwater Harvesting for Aquifer Recharge
CONTRACT NO: 2018-3049IGA
January, 2020

Final Report

Background: The purpose of this Agreement is to fund, construct and test a pilot Rainwater Harvesting and Aquifer Recharge Project in the Prescott Active Management Area (AMA). The concept is a new approach to rainwater harvesting that significantly increasing harvesting efficiency at a smaller cost per unit harvested than traditional rainwater systems. In particular, the approach was developed to address the proportionate share of overdraft in the Prescott AMA caused by the proliferation of exempt wells.

The Prescott AMA contains the highest density of private (exempt) wells in the State of Arizona. Approximately 10% of the State's exempt wells are located in a basin comprising less than 0.5% of the State's area. The exempt well issue provides many challenges to water management in a Safe-Yield AMA that currently has no imported water supplies. As existing water supplies that meet the State's Assured Water Supply standards for planned subdivisions become more difficult to obtain, development turns more toward the "lot-split with an exempt well" model to meet demands of growth.

The Coalition, the Prescott AMA Groundwater Users Advisory Committee (GUAC) and others have made various attempts to address the proliferation of exempt wells through a regulatory approach over the years without success. The Coalition Board directed the Technical Advisory Committee to compile and report on the past regulatory efforts (see Attachment A). This knowledge resulted in the Coalition seeking a new approach to water resource management for exempt well owners in the Prescott AMA - namely capturing and recharging enough rainwater to offset the aquifer overdraft caused by the pumping. This will be implemented through a voluntary approach with eventual incentives for owners of new wells.

The Town of Prescott Valley (Town) acted as fiscal and contracting agent on behalf of the Upper Verde River Watershed Protection Coalition (Coalition) for this grant funded project. For the purposes of this final report, the Coalition is the actionable party to complete the assigned tasks. Several partners contributed to this pilot project, in addition to ADWR, including Yavapai County providing direct funds ($3,998) and the demonstration building located at 1100 Orchard Court in Dewey, the Coalition ($8,483) and the Town of Prescott Valley direct contributions of metering, maintenance and reporting. The following narrative describes the concept being tested, the design, permitting, construction and test results after 18 months of operation.

Rainwater harvesting and aquifer recharge concepts:

Typical rainwater harvesting systems capture precipitation from rooftops and store it in a reservoir or cistern. Stored water is then typically used during the dry season by pumping it, carrying it by hand, or gravity flow to apply it to outdoor landscaping in order to reduce demand for potable water. However, most of the available rainwater is lost due to insufficient storage capacity. This concept paper proposes a lower cost solution to increase rainwater harvesting efficiency.

Typical rainwater harvesting system characteristics:

1. An efficient system is expensive. A large reservoir is required to maximize use of the available rainwater. For Central Yavapai County, rainwater collected during the (typically) wet months such as November through April would be used to meet landscaping water needs in May and June. A 2008 water conservation study (Regional Water Conservation Program Development and Recommended Implementation Plan, Larson and Associates, September 2008) concluded that a 2,875 gallon storage tank with a pumping and filtration system would cost $7,500.

2. Much of the potentially available rainwater is lost due to lack of storage capacity. In the example above (using a 2,500 square-foot roof area and an average of 8.5 inches of seasonal precipitation from November through April in Prescott) approximately 13,200 gallons of rainwater could be captured. The 2,875 gallon storage system is capable of storing only 22% of the available supply.
3. Typical rainwater harvesting systems may create an incentive for owners to install additional higher water using plants in their landscaping because of the perception of "free" water. This may actually drive up demand for potable water during times when the rainwater harvesting system runs dry.
4. Typical rainwater harvesting systems are often complex, incorporating pumps, filtration systems and backflow prevention devices – effectively creating a separate water system that needs to be maintained.
5. Water storage tanks are a potential breeding ground for mosquitos and must be managed to prevent algae growth.

Rainwater Harvesting and Aquifer Recharge:

The Coalition TAC determined that recharging the captured rainwater is less expensive and more efficient at collecting rainwater than the typical system. For homeowners that rely on private wells, this approach can extend the useable life of their well. Instead of constructing an expensive storage reservoir, a simple French drain (or "leach field") is installed on the well owner's property and plumbed directly to the rooftop gutter system. There are several advantages to this type of system:

1. The storage capacity of the system can be smaller than the typical rainwater harvesting system since it is designed to drain into lower stratum between precipitation events. Storage capacity need only be large enough to capture rain from one storm, not a full season of storms.
2. Costs are projected to be about 1/3 of the typical system with a large storage tank.
3. Less operational knowledge is required and maintenance costs are minimal.
4. All of the harvested rainwater is put back into the aquifer to benefit the well. The harvested yield is much higher than for most rainwater harvesting systems.
5. The water user operates one water system. The water source for outdoor landscaping still comes from the well.
6. No opportunity for mosquito breeding since the system drains within a day or two and is underground.
7. Once installed, the property above the French drains can be used for parking, etc.

Design:

The Coalition employed Civiltec Engineering to develop the design and obtain permits for the pilot-scale rainwater harvesting and aquifer recharge project. The site selected for the project is a Yavapai County facility storage structure located at 1100 Orchard Court in Dewey (Figure 1), northwest of the intersection of Highway 69 and Fain Road. One-half of one storage building roof, totaling 2,800 square feet, was selected to approximate the roof area of a typical single family residence. Gutters and downspouts were already in-place. Civiltec supervised an infiltration test at the site to size the French drain to hold a rainwater inflow rate equivalent to a 3" rain event in 1 day. Included in the design were a 3" diameter automatic read flow meter that was connected to the Town's Flexnet radio read meter system to measure inflow into the system. Hourly data was collected from the flow meter throughout the test period. Also included was an Otto Graf filter basket to prevent biological debris from entering the French drain and reducing or preventing infiltration to the aquifer. The plans and as-builts are included as Attachment B and C.

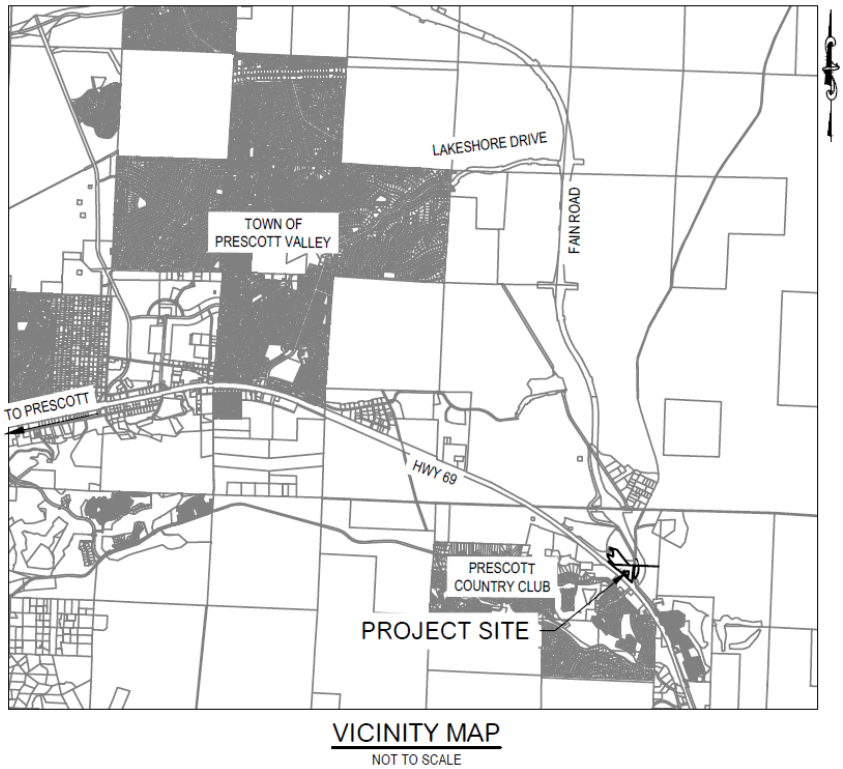

Figure 1. Location of Project Site

Permitting:
No building permit was necessary for the pilot test due to the fact that no modifications were made to the building itself. The Arizona Department of Environmental Quality (ADEQ) was contacted for a dry well registration permit. ADEQ determined that a permit was not necessary since the harvested rainwater did not contact the ground surface or other possible sources of contamination.

Construction:
In April, 2018, several local construction firms were invited to bid on the project. ALC Underground was selected as the low bidder. ALC Underground completed the construction of the project in mid-June, 2018. Construction costs were higher than anticipated largely due to the extra piping requirements to accommodate the distance to the French drain field to keep the recharge site outside of the parking lot, which also included removal and reconstruction of fencing.

Rainwater Harvesting and Aquifer Recharge

One of Two Recharge Trenches during construction (left) and completed (right)

Flow Meter (left), Roof and downspouts (right)

Test Results:
In addition to direct measurement of inflow to the French drain system, the Coalition monitored precipitation at the site based on a nearby Yavapai County Flood Control District gage located approximately 1/3 mile northwest (Lynx Creek Levee - site funded by a companion grant from ADWR – Contract No. 2018-2051 IGA).

Rainwater Harvest/Recharge Pilot Study			
Volume Harvested & Recharged, June 2018-March 2019			
Roof Area = 2,800 ft^2			
Month*	**Inflow measured by Flow Meter (gallons)**	**Precipitation (inches)(1)**	**Inflow measured by Roof Area-Volume Relationship (gallons)**
Jun-18	330	0.20	349
Jul- 2018 *	4,380	6.35	11,083
Aug-18	4,410	2.02	3,526
Sep-18	-	-	-
Oct-18	6,000	3.43	5,986
Nov-18	-	0.16	279
Dec-18	-	0.16	279
Jan-19	1,450	1.77	3,089
Feb-19	2,880	3.03	5,288
Mar-19	1,110	0.94	1,641
Apr-19	750	0.30	524
May-19	1,920	0.56	984
Jun-19	-	-	-
Jul-19	2,960	1.73	3,019
Aug-19	2,680	1.26	2,199
Sep-19	5,520	2.91	5,079
Oct-19	-	-	-
Nov-19	5,060	3.54	6,178
Dec-19 *	1,730	2.24	3,910
Total	41,180	18.46	53,414

* Flow meter malfunction

Uncertain accuracy of precipitation measurement during snow events in winter months

Overall, the relationship between metered inflow and the expected inflow calculated from the precipitation measurements and roof-area relationships are very close. Based on collected data, the Coalition places a conservative estimate of 53,000 gallons captured and recharged to the aquifer. The French drain field includes geo-fabric to prevent growth of deep rooted plants and no daylighting of the captured rainwater was observed. Therefore, all water entering the leach field is absorbed into the surrounding soil profile and eventually recharges the aquifer. The annual precipitation of 12.3 inches received during this test was below the long-term average of 13.6 inches for the site.

Some issues were experienced with both the flow meter and precipitation measurement systems. The flow meter experienced malfunctions due to debris caught in the meter that went past the filter basket in July 2018 and December 2019. The precipitation gage is not heated and only converts precipitation derived by snow if it is melted by natural conditions, increasing uncertainty of measured precipitation captured and recharged during snow events. There may also be some variation in the precipitation

amounts at the project site compared to the location of the precipitation gage.

The project site will continue to be maintained for as long as feasible. The flow meter will be removed and replaced with a straight pipe & flange. Yavapai County continues to monitor and maintain the precipitation gage.

Outreach Efforts:
Outreach efforts on this project include:

- Regular project updates at public meetings of the Coalition Board and TAC (2017-present)
- Watershed Task Force
- Public presentation or handouts at various public or group events including:
    - Prescott Valley Citizens academy
    - Prescott Area Small Business Group
    - Prescott Water Forum
    - Yavapai County Board of Supervisors
    - Yavapai County Contractors Home and Garden Show
    - Caldwell Banker Realtors Continuing Education Class
- Press Release (Attachment D)
- Rainwater Harvesting Brochure and Poster (Attachment E)

Lessons Learned:

- The filter basket requires frequent cleaning and maintenance. Further research has revealed other types of pre-filters that should be tested.
- The filter basket was installed below-grade, and although covered it is subject to flooding during large events.
- System costs increase the further the French drain is located from the rooftop area.
- The French Drain system employed here includes an excavated trench filled with leach rock. This rock provides storage capacity for captured rainwater while it infiltrates. The rock also supports the trench geometry and the ground above it. Since the pore space in the rock is around 35%, a trench approximately 3-times larger than necessary to hold the captured rainwater must be excavated. Other options such as leach chambers are available on the market and are significantly less expensive to install. The feasibility of these systems should be tested.
- Overall, the system has operated with little maintenance or interaction. There are no algae, or mosquito issues. The captured water requires no other treatment or maintenance to incorporate it back into a delivery system.

Conclusions:
Results from the rainwater harvesting and recharge pilot project proved the original concept that all rainwater that falls on the roof can be captured and stored. The costs for this initial project were higher than anticipated due largely to administrative, engineering and system design requirements. The Coalition still anticipates that the actual costs for a homeowner system will be substantially less expensive due to interviews with individuals who have experimented with similar systems.

The annual volume recharged is around 35,000 gallons, representing around one-third (1/3) to one-half (½) of the annual water budget for an average residence on an exempt well. Results from this pilot project support the concept that exempt well owners can offset their groundwater overdraft by installing this type of system.

Next Steps:
To be effective, the concepts proven by the pilot project need wide-spread adoption. Yavapai County and other jurisdictions with a large percentage of residences on exempt wells have expressed interest in developing incentive programs and eventually including system elements in building codes. However, at its October, 2019 meeting, the Coalition Executive Board instructed the Technical Advisory Committee to develop more system data with additional testing and employing different recharge systems, filtration systems, and locating systems in different locations in the Prescott AMA. The Coalition is applying for a WMAP grant through ADWR to further apply these concepts at different locations throughout the Prescott AMA. Visible sites in the Town of Chino Valley and City of Prescott have been identified. The locations are high traffic public areas and will build awareness of this concept, and allow for more effective outreach and public education.